



(19)

Europäisches Patentamt

European Patent Office

Office européen des brevets



(11)

EP 1 135 002 A2

(12)

## EUROPEAN PATENT APPLICATION

(43) Date of publication:  
19.09.2001 Bulletin 2001/38

(51) Int Cl.7: H04R 3/00

(21) Application number: 01302272.8

(22) Date of filing: 12.03.2001

(84) Designated Contracting States:  
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU  
MC NL PT SE TR  
Designated Extension States:  
AL LT LV MK RO SI

(30) Priority: 13.03.2000 JP 2000068933

(71) Applicant: SONY CORPORATION  
Tokyo 141 (JP)

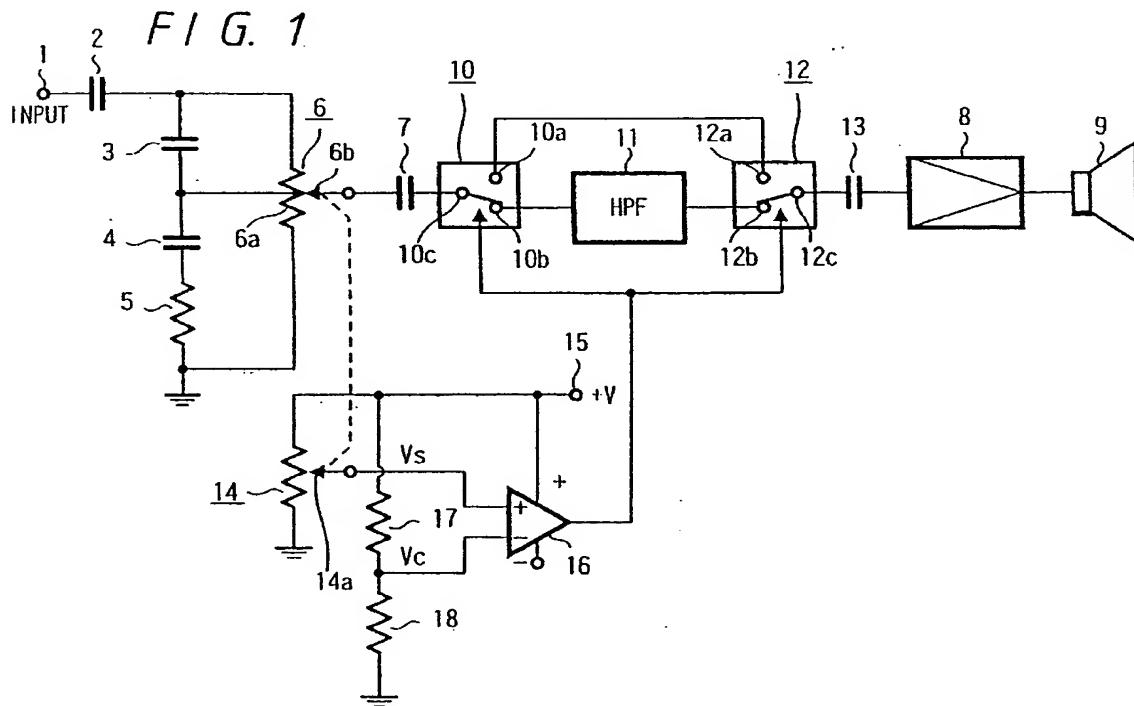
(72) Inventor: Maejima, Yoshimichi,  
c/o Sony Corporation  
Tokyo (JP)

(74) Representative: Ayers, Martyn Lewis Stanley  
J.A. KEMP & CO.,  
14 South Square,  
Gray's Inn  
London WC1R 5JJ (GB)

### (54) Speaker driving circuit

(57) To avoid adverse effect on sound quality when level of audio signal is raised, in a speaker driving circuit comprising ultralow range emphasizing means for emphasizing an ultralow range and a high-pass filter, switching means for removing the high-pass filter from

an audio signal path when an audio signal to be supplied to a speaker is below a medium level, and inserting the high-pass filter in the audio signal path when an audio signal to be supplied to the speaker is above the medium level is provided.



**Description**

**[0001]** The present invention relates to a speaker driving circuit suitably used for driving a relatively small speaker such as a speaker incorporated in a television receiver.

**[0002]** In a television receiver, for example, a relatively small speaker is used because the space is limited so that bass of an ultralow region cannot be reproduced well generally. In addition, human auditory characteristics vary according to levels of sound, and have a tendency as follows. As a sound level becomes low, sensitivity for an ultralow range is also lowered. Accordingly, when a sound level is low, there is a problem that it is difficult to hear ultralow bass.

**[0003]** In order to solve the above problem that it is hard to hear ultralow bass with its sound level being low, there has hitherto been known a method of using a so-called loudness control circuit, which makes frequency characteristics of a speaker driving circuit variable corresponding to a reproducing level of a sound level. By the loudness control circuit, frequency characteristics of a speaker driving circuit is changed to be relatively flat when a reproducing level is high, and a low range of frequency characteristics of the speaker driving circuit is made to boost when a reproducing level is low. When the reproducing level is low, a high range is also emphasized by the loudness control circuit. FIG. 5 is a circuit diagram showing an example of a loudness control circuit.

**[0004]** In explaining according to FIG. 5, reference numeral 1 in FIG. 5 denotes an audio signal input terminal for receiving an audio signal, this audio signal input terminal 1 is connected to a one end of a coupling capacitor 2, while the other end of this coupling capacitor 2 is grounded by way of a series circuit of capacitors 3, 4 and a resistor 5, and a connection mid point of the coupling capacitor 2 and capacitor 3 is grounded through a variable resistor 6, and a grounding mid point of the capacitors 3 and 4 is connected to an intermediate point of a resistor element 6a of this variable resistor 6.

**[0005]** An audio signal obtained at a movable element 6b of this variable resistor 6 is supplied into a power amplifier 8 through a coupling capacitor 7, and an audio signal obtained at the output side of this power amplifier 8 is supplied into a voice coil of a speaker 9, and the diaphragm of this speaker 9 is oscillated to emit a sound.

**[0006]** As shown in FIG. 6, frequency characteristics of an audio signal supplied from the power amplifier 8 to the speaker 9 is flat from the ultralow range to the high range when the reproducing level is high. When the reproducing level is low, the ultralow range and the high range is boosted. Therefore, irrespective of a high or low level of reproduction, ultralow range sound can be heard. Furthermore, the frequency characteristics extend to the ultralow range so that bass of high quality can be obtained without phase loss of the signal.

**[0007]** However, with a relatively small speaker such

as a speaker incorporated in a television receiver, when the level of audio signal is raised and the speaker 9 is driven by the ultralow range signal of high level, the diaphragm of the speaker 9 itself does oscillates, but cannot drive the air sufficiently. So, adverse effects are caused on the sound quality.

**[0008]** The present invention is devised in the light of the above problems, and it is an object thereof to avoid adverse effects on the sound quality even if the level of the audio signal is raised.

**[0009]** The present invention presents a speaker driving circuit comprising a volume adjusting means for adjusting an output level of an audio signal supplied to a speaker and an ultralow bass emphasizing circuit frequency characteristics of which is variable corresponding to an adjusted state of the volume adjusting means, which further comprises level detecting means for detecting an adjusted state of the volume adjusting means and ultralow bass component reducing means for, when it is detected by the level detecting means that the volume adjusting means is adjusted to make an output level of the audio signal become higher than a specified level, reducing an ultralow bass component of the audio signal.

**[0010]** According to the present invention, as far as the audio signal is below the medium level, the speaker is driven by a signal extended in the frequency characteristic to the ultralow range, the bass of high quality is obtained without phase loss, but when the audio signal is above the medium level, since the ultralow range is cut off by the high-pass filter, clip or the like does not occur, and the diaphragm of the speaker does not oscillate in the ultraslow range, so that there is no adverse effect on the sound quality.

**[0011]** The invention will be more clearly understood from the following description, given by way of example only, with reference to the accompanying drawings, in which:

**40** FIG. 1 is a block diagram showing an example of an embodiment of a speaker driving circuit of the invention;

FIG. 2 is a diagram for explaining FIG. 1;

**45** FIG. 3 is a block diagram showing another example of the embodiment of the speaker driving circuit of the invention;

FIG. 4 is a diagram for explaining FIG. 3;

FIG. 5 is a block diagram showing a prior art of a speaker driving circuit; and

**50** FIG. 6 is a diagram for explaining FIG. 5.

**[0012]** An embodiment of a speaker driving circuit of the invention is explained by referring to FIG. 1 and FIG. 2. In FIG. 1, the parts corresponding to FIG. 5 are identified with the same reference numerals.

**[0013]** In FIG. 1, reference numeral 1 denotes an audio signal input terminal for receiving an audio signal, this audio signal input terminal 1 is connected to a one

end of a coupling capacitor 2, while the other end of this coupling capacitor 2 is grounded by way of a series circuit of capacitors 3, 4 and a resistor 5, and a connection mid point of the coupling capacitor 2 and capacitor 3 is grounded through a variable resistor 6, and a grounding mid point of the capacitors 3 and 4 is connected to an intermediate point of a resistor element 6a of this variable resistor 6. The capacitor 3, capacitor 4, resistor 5, and variable resistor 6 comprise the loudness control circuit.

[0014] In this example, a movable element 6b of this variable resistor 6 is connected to a movable contact point 10c of a changeover switch 10 through the coupling capacitor 7, and one fixed contact point 10a of this changeover switch 10 is connected to one fixed contact point 10a of a changeover switch 12, and other fixed contact point 10b of this changeover switch 10 is connected to another fixed contact point 12b of the changeover switch 12 through a high-pass filter 11 for cutting off the ultralow range.

[0015] An audio signal obtained at a movable contact point 12c of this changeover switch 12 is supplied to a power amplifier 8 through a coupling capacitor 13, and an audio signal obtained at the output side of this power amplifier 8 is supplied to a voice coil of a speaker 9, thereby oscillating the diaphragm of the speaker 9 to emit a sound.

[0016] In this embodiment, a level detecting variable resistor 14 is provided. That is, a power source terminal 15 for obtaining a positive DC voltage of +V is grounded through this level detecting variable resistor 14, and the movable element 14a of this level detecting variable resistor 14 is interlocked with the movable element 6b of the variable resistor 6 for audio level adjustment.

[0017] In this case, a detection voltage level Vs depending on the position of the movable element 6b of the variable resistor 6 for audio level adjustment, i.e., an audio volume adjusted state, is obtained at the movable terminal 14a of the level detecting variable resistor 14.

[0018] This detection voltage level Vs obtained at the movable element 14a of the level detecting variable resistor 14 is applied to a non-inverting input terminal + of an operational amplifier 16 for composing a comparator.

[0019] The power source terminal 15 is grounded through a series circuit of resistors 17 and 18 for division, so that the voltage obtained at the connection mid point of the resistors 17 and 18 may be voltage Vc equal to the detection voltage level Vs obtained at the movable element 14a of the level detecting variable resistor 14 when the level of the audio signal obtained at the movable element 6b of the variable resistor 6 may be a medium level, for example, the level applied to the speaker 9 is -30 dB.

[0020] The voltage Vc obtained at the connection mid point of the resistors 17 and 18 is applied to an inverting input terminal - of the operation amplifier 16. Therefore, on the output side of the operational amplifier 16, when the detection voltage level Vs obtained at the movable

element 14a of the level detecting variable resistor 14 ranges from 0 V to voltage Vc, that is, the level of audio signal supplied to the voice coil of the speaker 9 is below the medium level, for example, below -30 dB, it is low level "0", and when the detection voltage level Vs obtained at the movable element 14a is above voltage Vc, that is, when the level of audio signal supplied to the voice coil of the speaker 9 is above the medium level, for example, above -30 dB, it is high level "1".

[0021] In the embodiment, by the output of the operational amplifier 16, the movable contact points 10c and 12c of the changeover switches 10 and 12 are controlled. That is, when the output side of the operational amplifier 16 is low level "0", the movable contact points 10c and 12c of the changeover switches 10 and 12 are connected to the fixed contact points 10a and 12a of the changeover switches 10 and 12, and the high-pass filter 11 is inserted into the audio signal path.

[0022] On the other hand, when the output side of the operational amplifier 16 is high level "1", the movable contact points 10c and 12c of the changeover switches 10 and 12 are connected to the other fixed contact points 10b and 12b, and the high-pass filter 11 is inserted the audio signal path.

[0023] Therefore, the frequency characteristic of the audio signal supplied to the voice coil of the speaker 9 is as shown in FIG. 2, and when the audio signal level is below the medium level, for example, below -30 dB (indicated by a broken line), the characteristic is emphasized in the ultralow range, and at this time since the voice coil of the speaker 9 is driven by an audio signal extended in the frequency characteristic to the ultralow range, the bass of high quality is obtained without phase loss.

[0024] When the level of the audio signal supplied in the voice coil of the speaker 9 is above the medium level, for example, above -30 dB, the frequency characteristic of the audio signal is as shown in FIG. 2, that is, the ultralow range is cut off by the high-pass filter 11, and hence clip or the like does not occur, and moreover since the diaphragm of the speaker 9 does not oscillate in the ultralow range, there is no adverse effect on the sound quality.

[0025] As explained above, according to the embodiment, when the audio signal is below the medium level, for example, below -30 dB (containing an ordinary audio level in television receiver), the ultralow range is emphasized, and the voice coil of the speaker 9 is driven by an audio signal extended in the frequency characteristic to ultralow range, and therefore the bass of high quality is obtained without phase loss, and when the audio signal is above the medium level, for example, above -30 dB, the ultralow range is cut off by the high-pass filter 11, and hence clip or the like does not occur, and moreover since the diaphragm of the speaker 9 is not oscillated in the ultralow range, there is no adverse effect on the sound quality.

[0026] FIG. 3 shows another example of the embod-

iment of the speaker driving circuit of the invention. In FIG. 3, the same parts corresponding to those in FIG. 1 are identified with same reference numerals, and detailed description is omitted. In this example in FIG. 3, unlike the example in FIG. 1, the ultralow range is not emphasized when the level of an audio signal is extremely low.

[0027] In FIG. 3, an audio signal input terminal 1 is connected to a one end of a coupling capacitor 2, the other end of this coupling capacitor 2 is connected to a fixed contact point 20a of a changeover switch 20 through a capacitor 3, a movable contact point 20c of this changeover switch 20 is grounded by way of a series circuit of a capacitor 4 and a resistor 5, a connection mid point of the capacitor 4 and resistor 5 is connected to the other fixed contact point 20b of the changeover switch 20, the connection mid point of the coupling capacitor 2 and capacitor 3 is grounded through a variable resistor 6, and the movable contact point 20c of this changeover switch 20 is connected to an intermediate point of a resistor element 6a of the variable resistor 6. The movable element 6a of the variable resistor 6 is connected to the movable contact point 10c of the changeover switch 10.

[0028] In this case, when the movable contact point 20c of the changeover switch 20 is connected to one fixed contact point 20a, the same as shown in FIG. 1, a loudness control circuit for emphasizing the ultralow range is inserted in the audio signal path, and when the movable contact point 20c of this changeover switch 20 is connected to another fixed contact point 20b, the audio signal supplied to the audio signal input terminal 1 is supplied directly to the variable resistor 6, so that the ultralow range is not emphasized.

[0029] Also in the example shown in FIG. 3, a power source terminal 15 for obtaining a positive DC voltage of +V is grounded through a level detecting variable resistor 14, and the movable element 14a of this level detecting variable resistor 14 is interlocked with the movable element 6b of the variable resistor 6 for audio level adjustment. In this case, at the movable element 14a of the level detecting variable resistor 14, a detection voltage level Vs depending on the level of the audio signal obtained at the movable element 6b of the variable resistor 6 for audio level adjustment is obtained.

[0030] In this example, the detection voltage level Vs depending on the audio signal level obtained at the movable element 14a of the level detecting variable resistor 14 is applied to a non-inverting input terminal + of an operational amplifier 21 and an inverting input terminal - of an operational amplifier 22 for composing a comparator.

[0031] Also in the example, by applying a voltage VH at a fixed voltage input terminal 21a, of which the level of an audio signal obtained by the movable element 6b of the variable resistor 6 is equal to a medium level, for example, the level supplied to the speaker 9 is equal to

the detection voltage level Vs obtained at the movable element 14a of the level detecting variable resistor 14 corresponding to -30 dB, the voltage VH obtained at this fixed voltage input terminal 21a is applied to the inverting input terminal - of the operational amplifier 21.

[0032] Further in the example, by applying a voltage VL at a fixed voltage input terminal 22a, of which the level of an audio signal obtained at the movable element 6b of the variable resistor 6 is low, for example, the level supplied to the speaker 9 is equal to the detection voltage level Vs obtained at the movable element 14a of the level detecting variable resistor 14 corresponding to -55 dB, the voltage VL obtained at this fixed voltage input terminal 22a is supplied to the non-inverting input terminal + of the operational amplifier 22.

[0033] Therefore, at outputs X<sub>1</sub> and X<sub>2</sub> of the operational amplifiers 21 and 22, when the detection voltage level Vs obtained at the movable element 14a of the level detecting variable resistor 14 shown in Table 1 is 0 V

20 to VL, output X<sub>1</sub> is low level "0" and output X<sub>2</sub> is high level "1", and when the detection voltage level Vs is VL to VH, output X<sub>1</sub> is low level "0" and output X<sub>2</sub> is low level "0", and further when the detection voltage level Vs is VH to +V, output X<sub>1</sub> is high level "1" and output X<sub>2</sub>

25 is low level "0".

Table 1

Vs	0-VL-VH+V
X <sub>1</sub>	"0" "0" "1"
X <sub>2</sub>	"1" "0" "0"

[0034] In this example, the outputs X<sub>1</sub> and X<sub>2</sub> of the operational amplifiers 21 and 22 are supplied to a switch control circuit 23 through resistors. This switch control circuit 23 controls to change over the movable contact points 20c, 10c, and 12c of the changeover switches 20, 10 and 12 depending on the outputs X<sub>1</sub> and X<sub>2</sub> of the operational amplifiers 21 and 22.

[0035] That is, the movable contact point 20c of this changeover switch 20 is connected to the other fixed contact point 20b until the detection voltage level Vs obtained at the movable element 14a of the level detecting variable resistor 14 becomes the voltage VL, and when this detection voltage level Vs exceeds the voltage VL, the movable element 20c is connected to one fixed contact point 20a, and at this time the loudness control circuit is inserted in the audio signal path, and the ultralow range is emphasized.

[0036] The movable contact points 10c and 12c of the changeover switches 10 and 12 are connected to the fixed contact points 10a and 12a respectively until the detection voltage level Vs obtained at the movable element 14a of the level detecting variable resistor 14 reaches the voltage VH, and at this time the high-pass filter 11 is not inserted in the audio signal path.

[0037] When the detection voltage level Vs exceeds

the voltage VH, the movable contact points 10c and 12c are connected to the other fixed contact points 10b and 12b, and the high-pass filter 11 is inserted in the audio signal path at this time, and the ultralow range is cut off. The example in FIG. 3 is the same as the configuration in FIG. 1 in all other respects.

[0038] The example in FIG. 3 is thus composed, and the frequency characteristic of the audio signal supplied to the voice coil of the speaker 9 is as shown in FIG. 4, and it is a flat characteristic when the audio signal level is low, for example, below -55 dB, and hence noise is not emphasized. When this audio signal level is higher than this low level and lower than the medium level, for example, around -55 dB to -30 dB, the ultralow range is emphasized in this frequency characteristic, and the voice coil of the speaker 9 is driven by the audio signal extended in the frequency characteristic to the ultralow range, so that the bass of high quality is obtained without phase loss.

[0039] When the level of the audio signal supplied to the voice coil of the speaker 9 is higher than the medium level, for example, more than -30 dB, the frequency characteristic of the audio signal is as shown in FIG. 4, and the ultralow range is cut off by the high-pass filter 11, and clip or the like does not occur, and the diaphragm of the speaker 9 is not oscillated in the ultralow range, so that no adverse effect is caused on the sound quality.

[0040] Therefore, it is easily understood that the same action and effect as in the example in FIG. 1 are obtained also in the example in FIG. 3.

[0041] The foregoing examples are analog compositions, a digital composition may be also formed by using DSP (digital signal processor) and others.

[0042] The invention is not limited to the illustrated examples alone, but may be changed and modified within the scope of the invention.

[0043] As explained above, according to the present invention, when the audio signal is below the medium level, for example, below -30 dB (a containing ordinary audio level in a television receiver), the ultralow range is emphasized, and the voice coil of the speaker is driven by an audio signal extended in the frequency characteristic to the ultralow range, and therefore the bass of high quality is obtained without phase loss, and when the audio signal is above the medium level, for example, above -30 dB, the ultralow range is cut off by the high-pass filter, and hence clip or the like does not occur, and moreover since the diaphragm of the speaker is not oscillated in the ultralow range, there is no adverse effect on the sound quality.

[0044] Having described preferred embodiments of the present invention with reference to the accompanying drawings, it is to be understood that the present invention is not limited to the above-mentioned embodiments and that various changes and modifications can be effected therein by one skilled in the art without departing from the spirit or scope of the present invention as defined in the appended claims.

## Claims

1. A speaker driving circuit comprising a volume adjusting means for adjusting an output level of an audio signal supplied to a speaker and an ultralow bass emphasizing circuit frequency characteristics of which is variable corresponding to an adjusted state of said volume adjusting means, further comprising:  
5 level detecting means for detecting an adjusted state of said volume adjusting means; and ultralow bass component reducing means for, when it is detected by said level detecting means that said volume adjusting means is adjusted to make an output level of the audio signal become higher than a specified level, reducing an ultralow bass component of the audio signal.
2. The speaker driving circuit of claim 1, wherein said volume adjusting means is a variable resistor for adjusting volume, and wherein said level detecting means is a variable resistor for detecting a level, being coupled to the variable resistor for adjusting volume.
3. The speaker driving circuit of claim 1 or 2, wherein said ultralow bass component reducing means is a high-pass filter for cutting an ultralow range inserted selectively in an audio signal path corresponding to an adjusted state of said volume adjusting means.

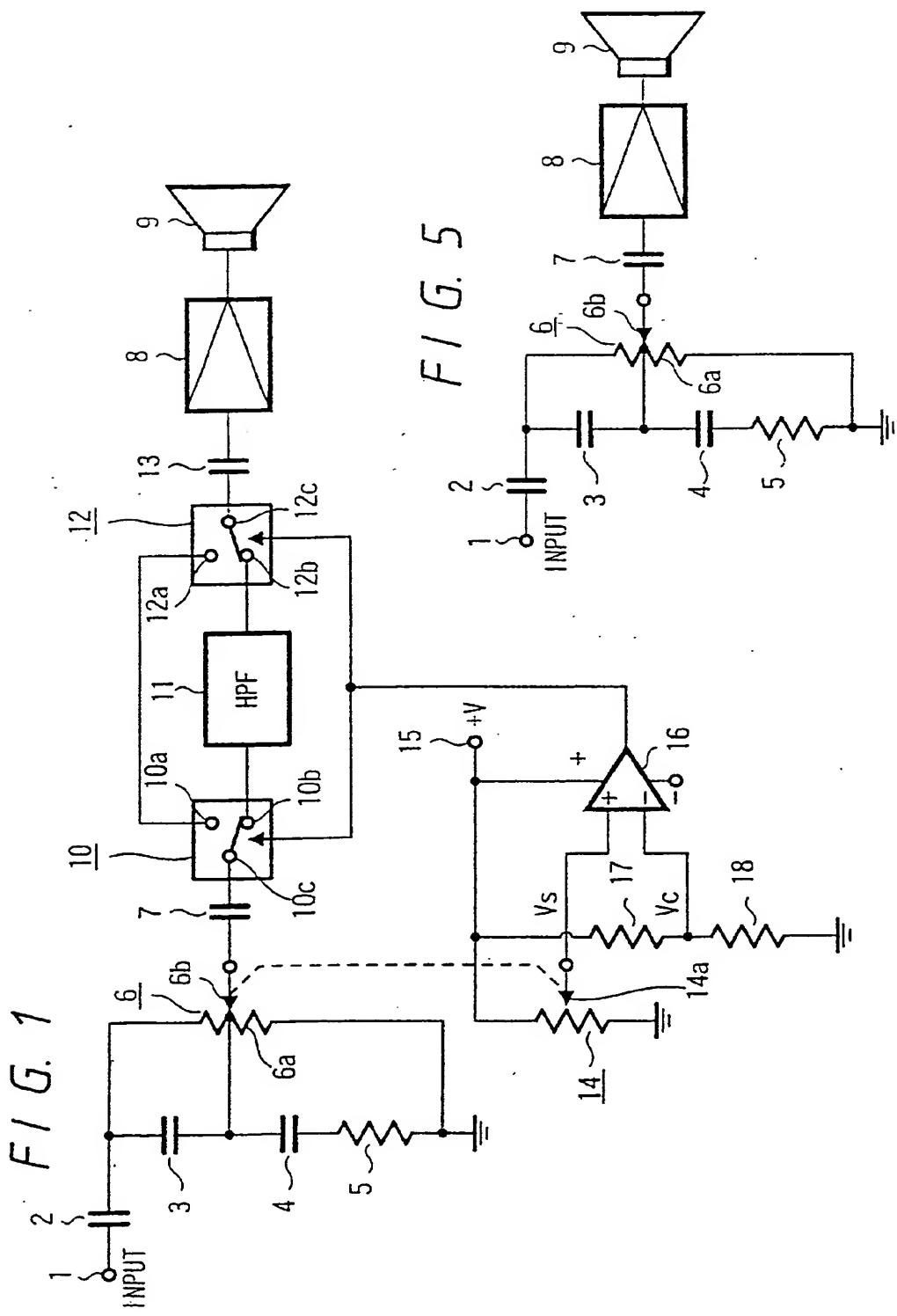


FIG. 2

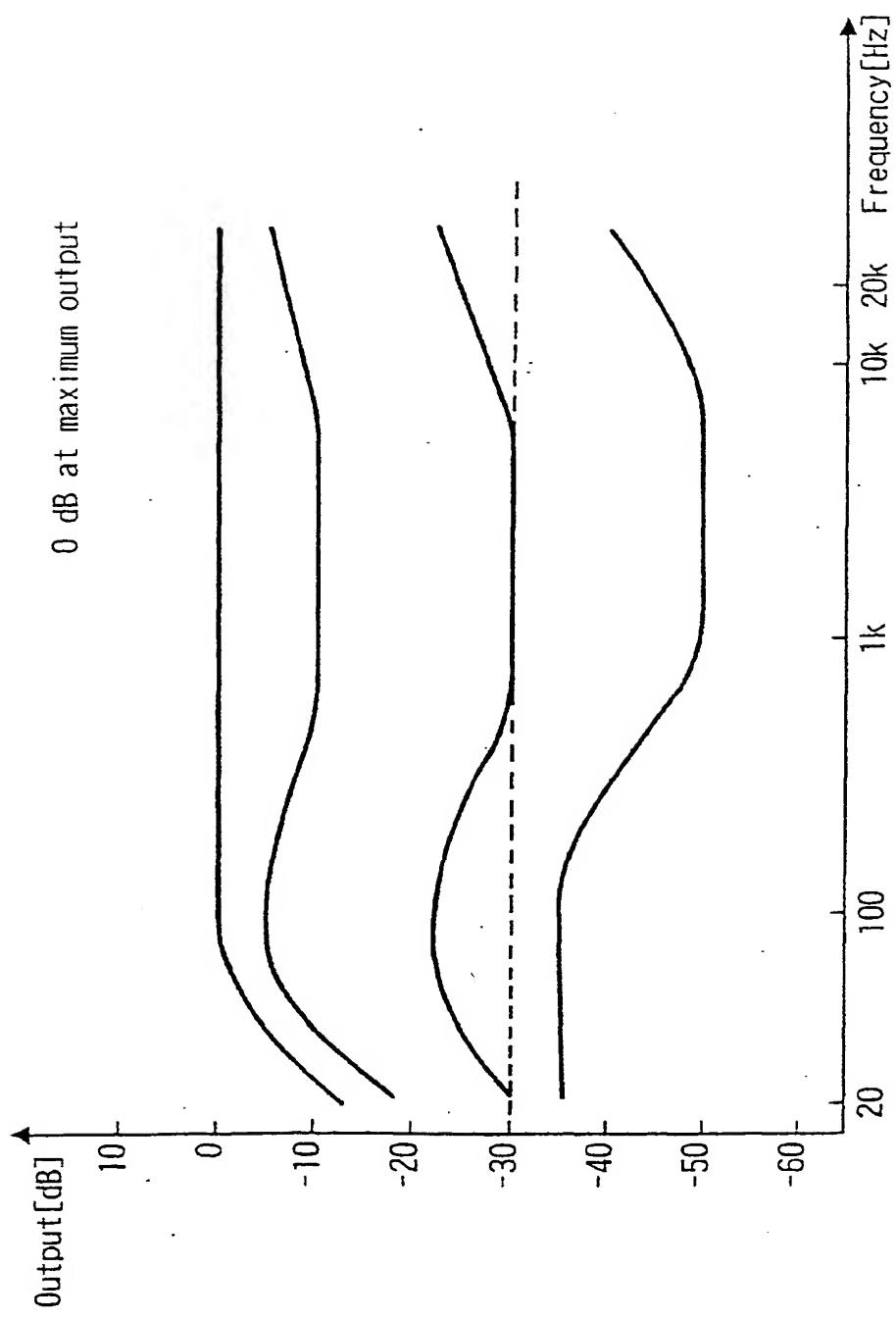


FIG. 3

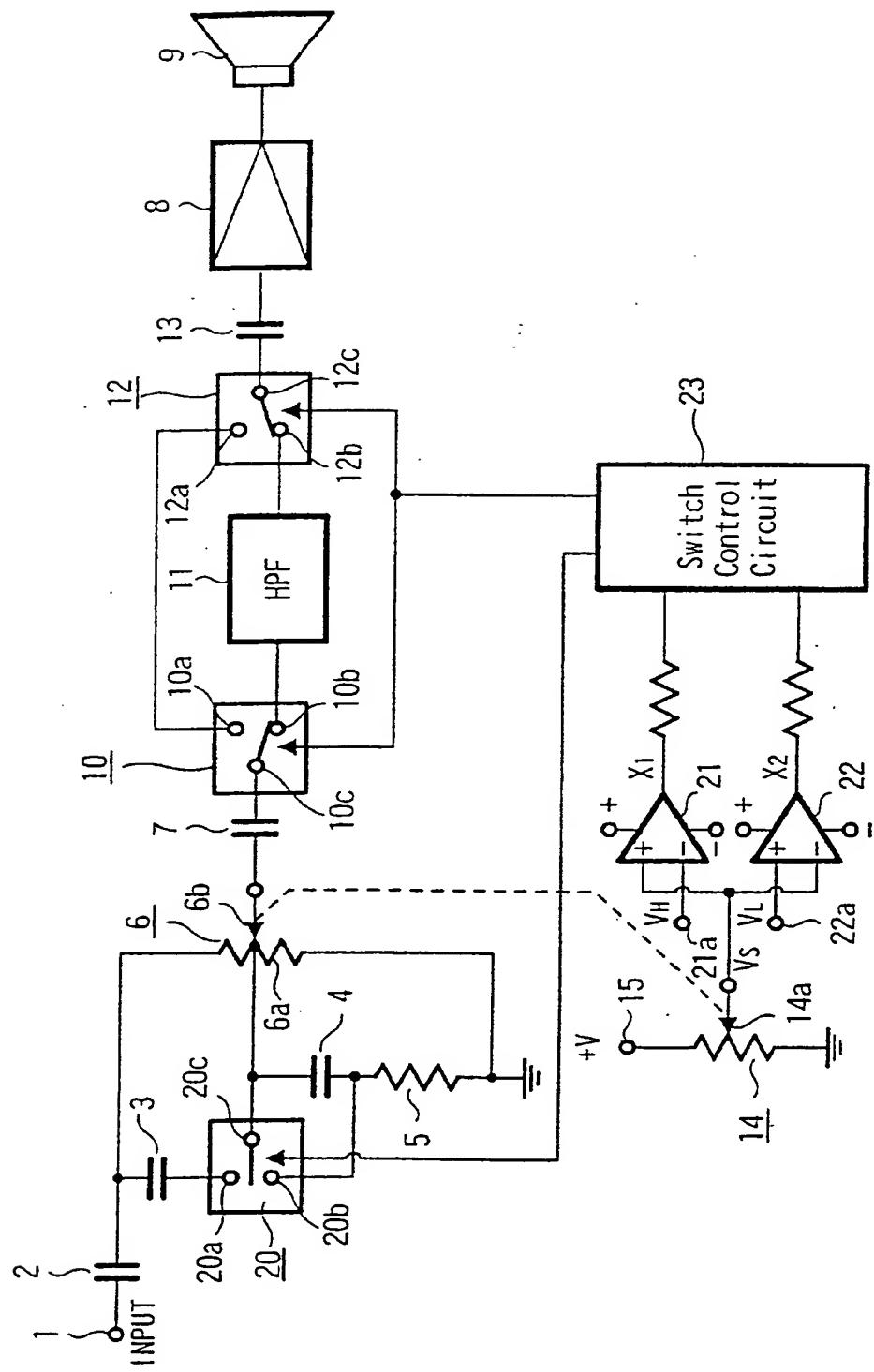


FIG. 4

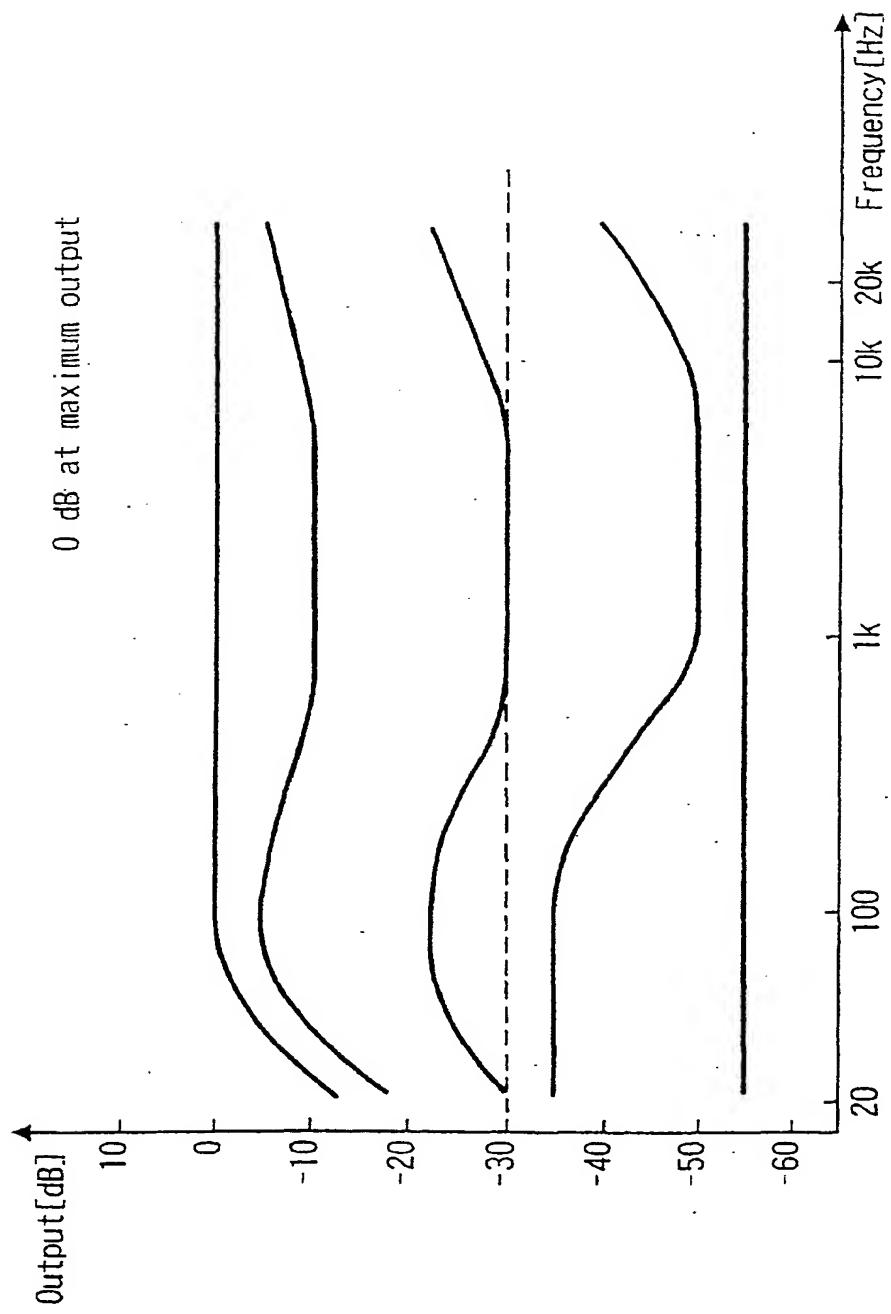


FIG. 6

